

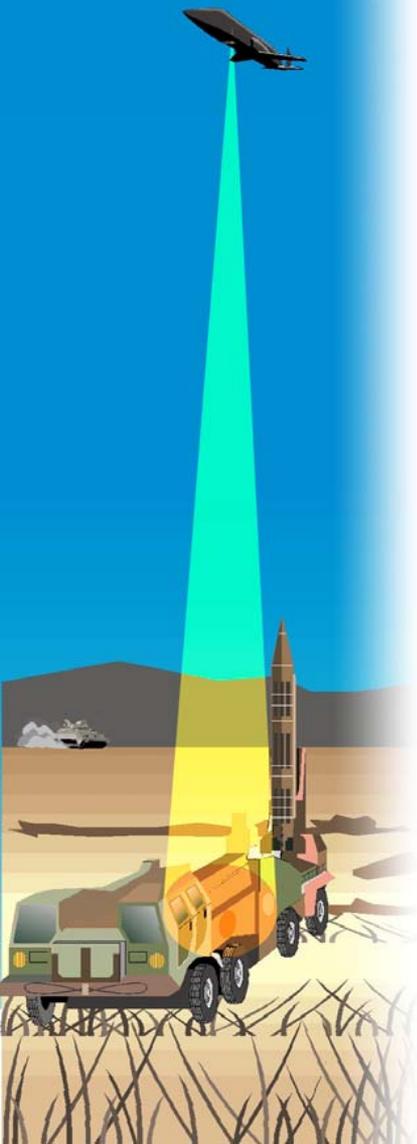


Industry Day

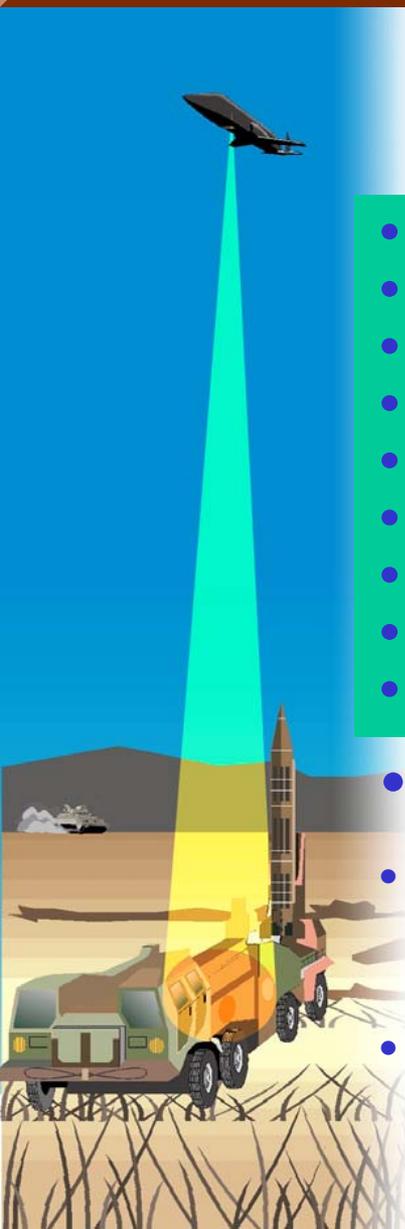
Dynamic Optical Tags

12 March 2003

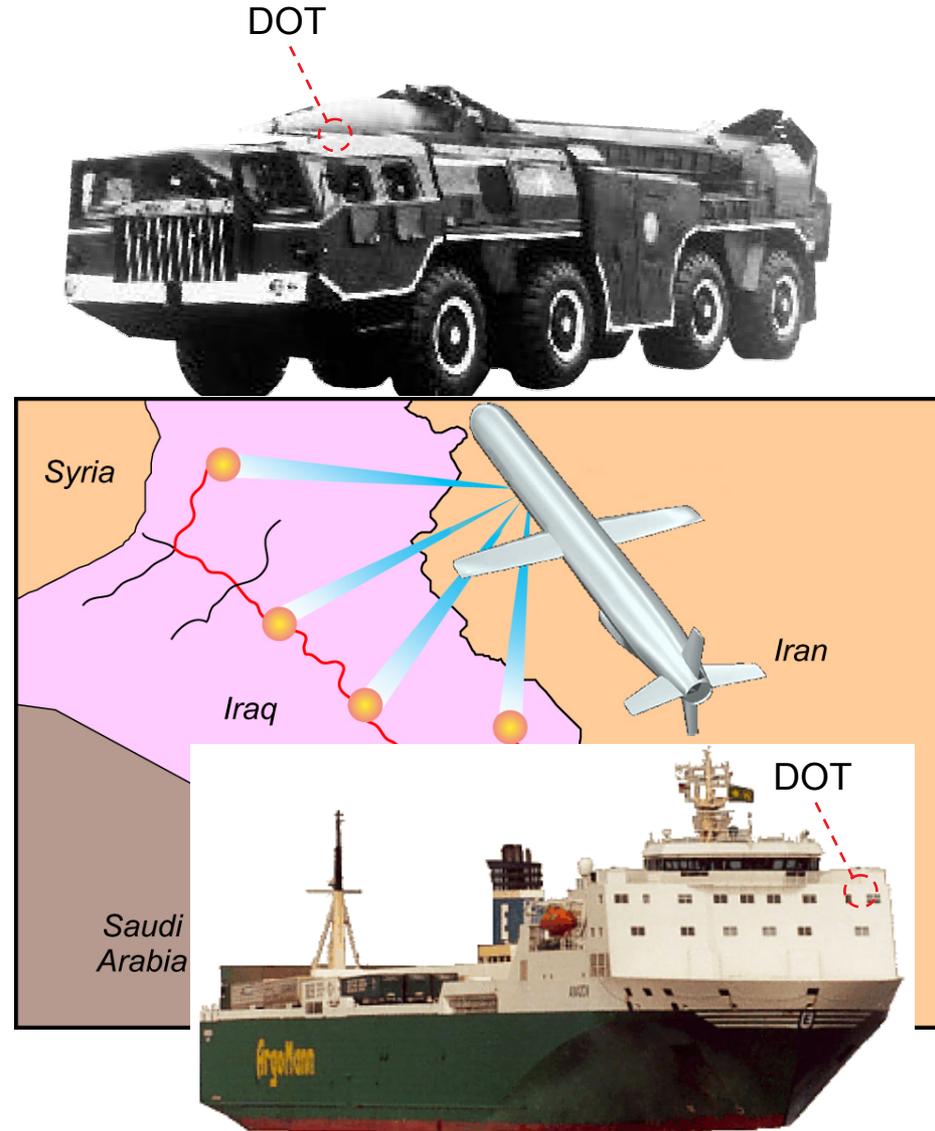
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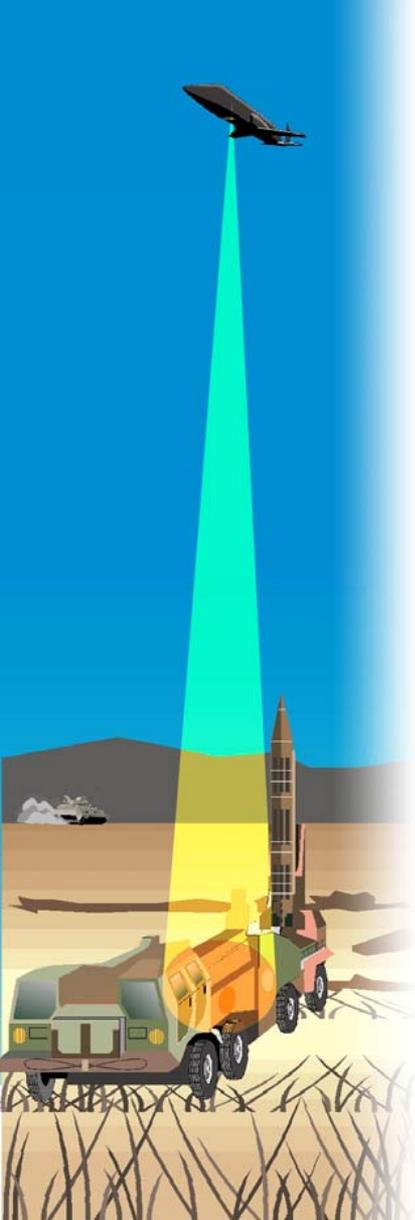


Clandestine 2-way tag interrogation at 10 Km

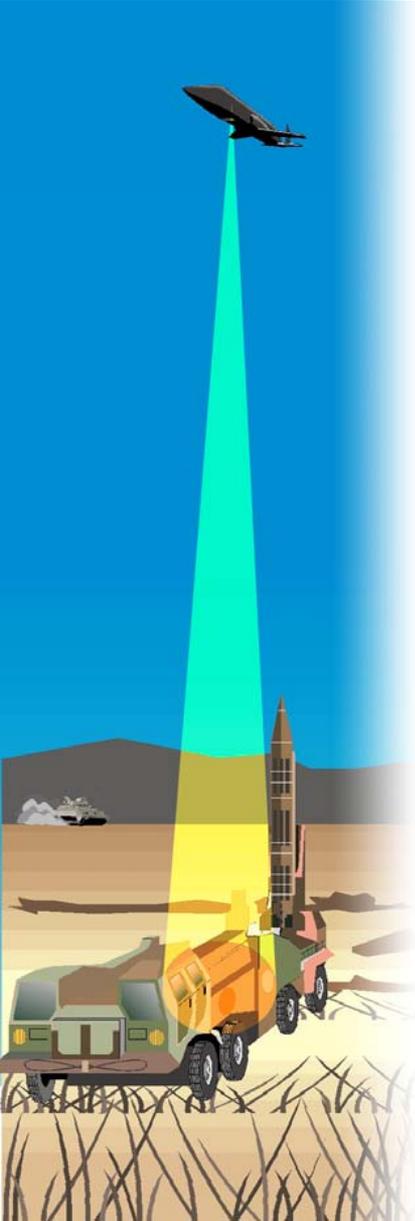
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- An illustration on the left side of the slide shows a dark aircraft in the sky emitting a bright, conical beam of light that illuminates a ground target. The target is a green military truck with a yellow trailer, parked in a desert-like environment with some vegetation in the foreground. The beam of light is depicted with a gradient from blue at the top to yellow at the bottom.
- Long range
 - Precision location
 - Covert
 - Dynamically configurable
 - Optically interrogated
 - Passive
 - Long-life
 - Scaleable
 - Airborne & handheld interrogators
- 25 x 25 x 5 mm³
 - -40° to +70° C
 - >100 kb/s data rate
 - >10 km range
 - >2 mos. Operation
 - ± 60° Acceptance
 - <\$100/tag
 - Non-visually alerting
- Small retro-reflecting optical tags
 - Non-RF identification, location, and tracking
 - Targets, Assets, Precision spatial reference points
 - Covert 2-way data exchange in friendly and denied areas
 - Sensors, Mission data, Logistics, Status,

- DOTs provide unique identification and precision location for every tagged target in view
- As platform moves throughout a region the DOT can record location information (via GPS) as well as other data (imagery, audio,...) that can provide vital information and decrease target ambiguity
- DOTs should be persistent despite harsh environmental conditions, and long time between application and interrogation
- DOTs are interrogated by some asset (UAV, P-3, U-2, handheld,...)
- DOTs fast optical link allow non RF data exfiltration





- **Develop modulating optical tags**
 - Small and thin retro-reflecting optics
 - Wide operation temperature range
 - Non-visually alerting
- **Develop a tag specific transceiver system**
 - Eye-safe @ tag
 - Short search and interrogate timeline
 - Automated scanning
 - Airborne and handheld versions



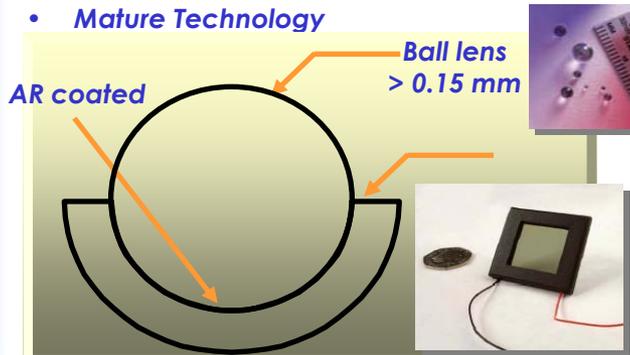
Ferroelectric Liquid Crystal Modulator

Advantages

- Wide FOV
- Wide Operational $\Delta\lambda$
- Low Power
- Mature Technology

Limitations

- Flexible LCD Technology
- Temp Range -10° to 60° C
- Switch Speed \sim Kb/s



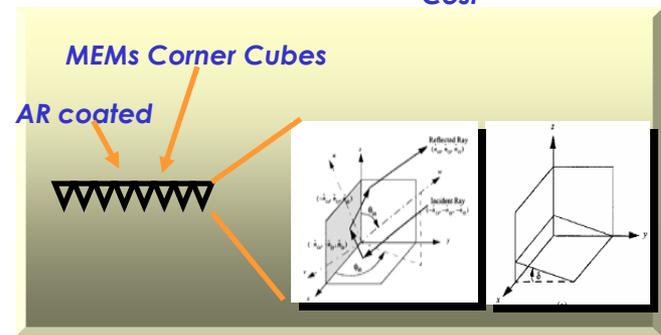
MicroElectroMechanical CCR

Advantages

- 100% Contrast
- Low Power

Limitations

- Switch Speed
- Surface Flatness
- Small Clear Aperture
- Cost



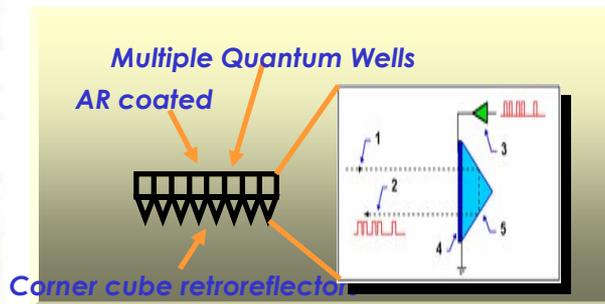
Multiple Quantum Well Retroreflectors

Advantages

- High Data Rate \sim Mb/s
- Eye-safe λ
- Low Power

Limitations

- Narrow Waveband
- Modulation Depth \sim 1 dB
- Clear Aperture $<$ 1cm dia.
- Cost



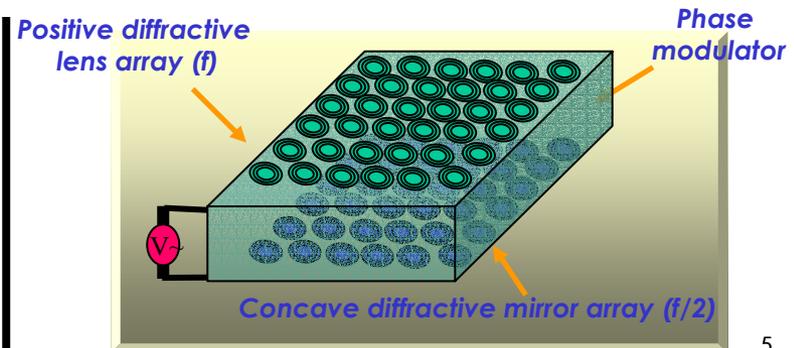
Thin Film Diffractive Modulating Retroreflector

Advantages

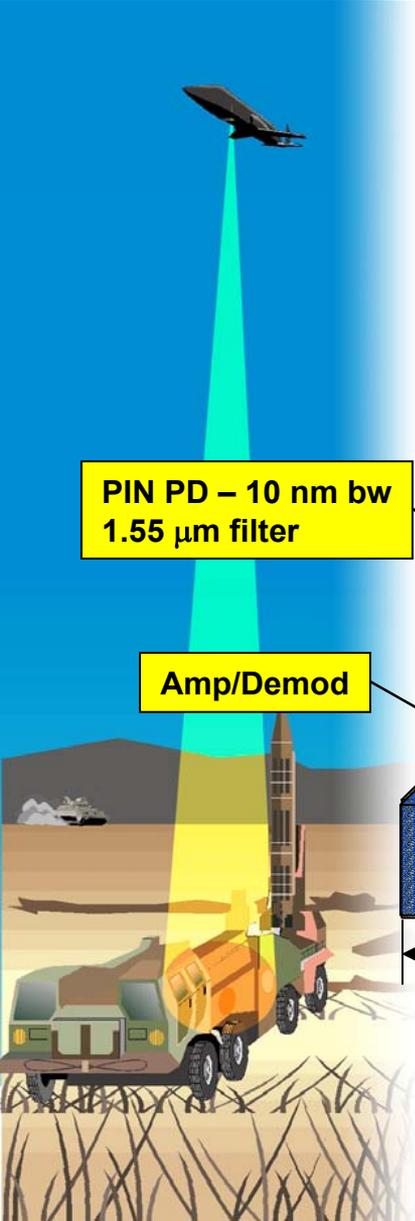
- Ultra Thin \sim 1mm
- Low Cost
- Modulation ν

Limitations

- Reflection efficiency
- FOV
- Optical Bandwidth



- **InGaAs PIN Photodiode** ($0.5 \times 0.5 \times 0.015 \text{ mm}^3$)
 Response: 1 A/W @ 1.55 μm
 Operating T: -20 to +85 $^\circ\text{C}$
 Storage T: -55 to +125 $^\circ\text{C}$
 Dark current: 5 nA @ 5 V (7 μA -hrs total for 2 mos.)
- **FLC Retroreflecting Modulator** ($25 \times 20 \times 2 \text{ mm}^3$)
 1 ma @ 10 Khz \rightarrow 2 ma-hrs for 2 hrs.
- **Amplifier/Demodulator** ($5 \times 10 \times 5 \text{ mm}^3$)
 50 μA \rightarrow 72 mA-hrs total for 2 mos.

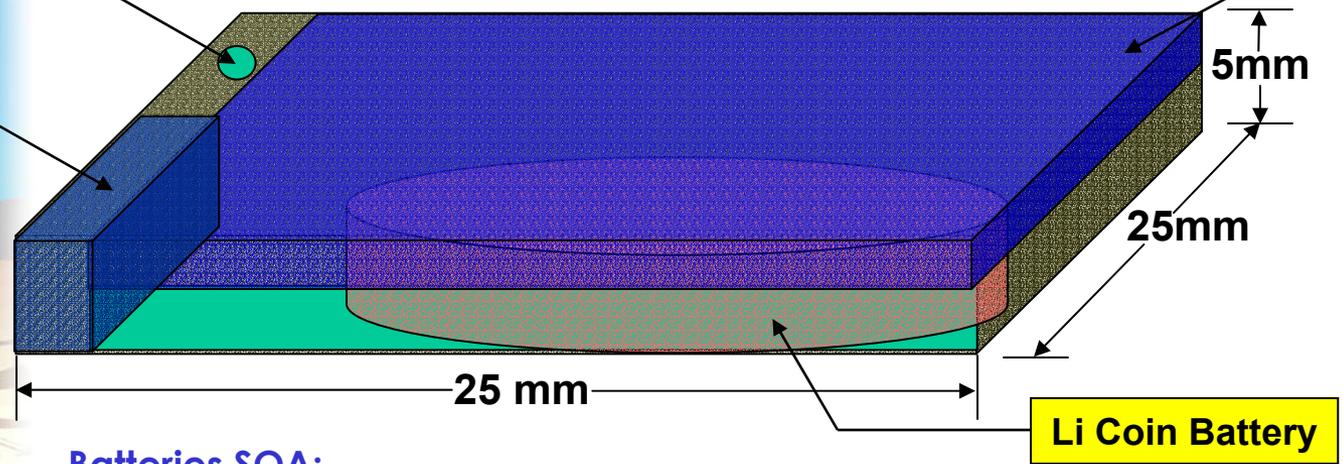


PIN PD – 10 nm bw
1.55 μm filter

Amp/Demod

Total current required ~ 75 mA-hrs

Retroreflecting
Modulator
Material

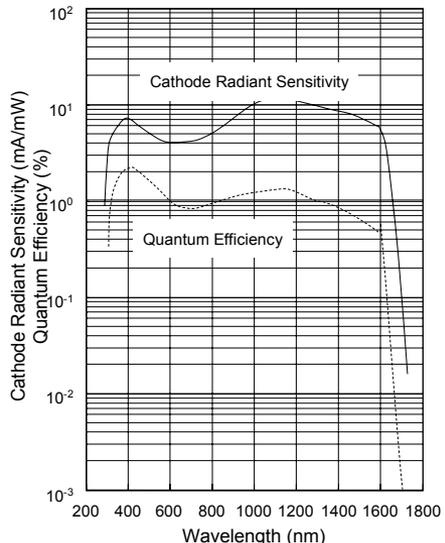
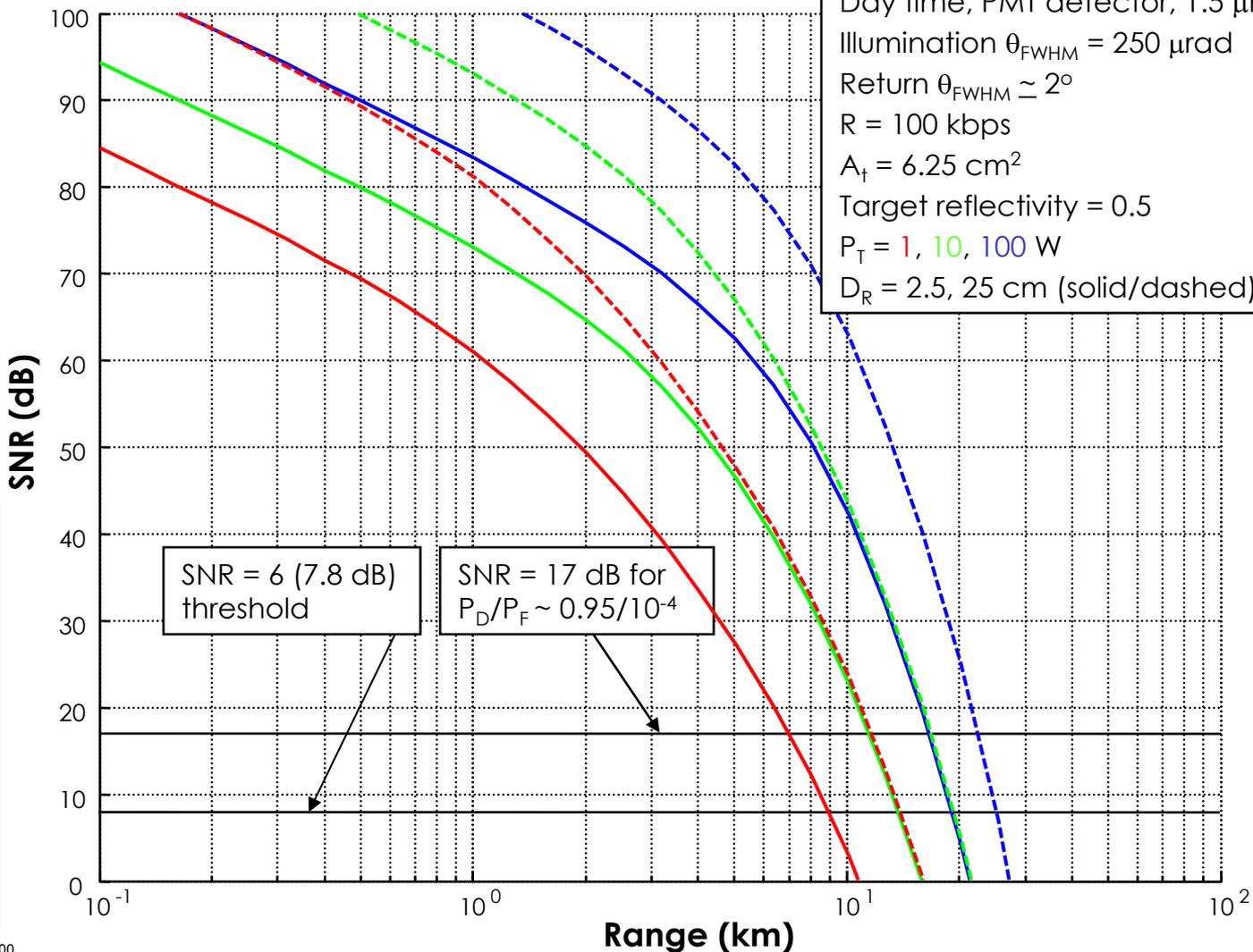


Batteries SOA:

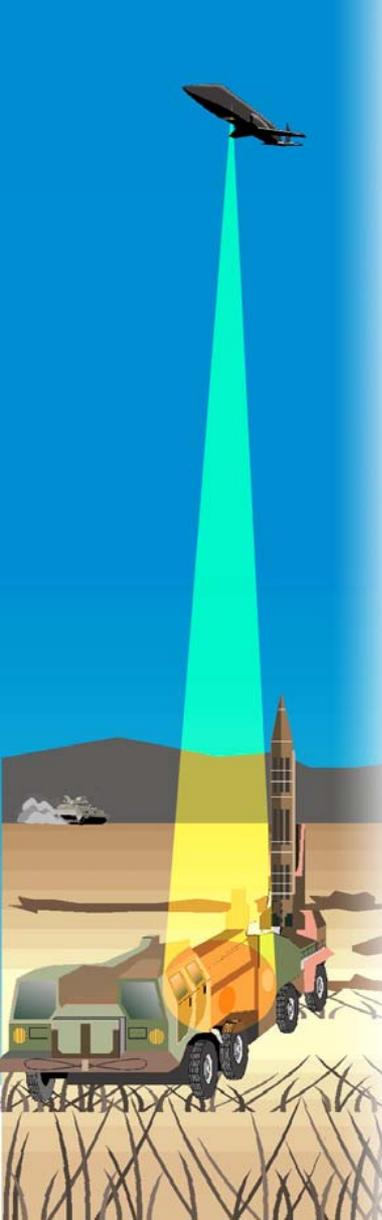
- Li coin (Seiko): $f=16 \text{ mm}$, $h=3.2 \text{ mm}$, 120 ma-hrs (commercial)
- Li polymer thin film (Matsushita): $f=20 \text{ mm}$, $h=0.4 \text{ mm}$, 18 ma-hrs (new)
- Zn-MnO₂ thin film (Power Paper): 2.5 mA-hrs/cm², $h=0.5 \text{ mm}$ (developmental)



Ball Lens Retro Incoherent Ladar SNR



Sizing the Interrogator

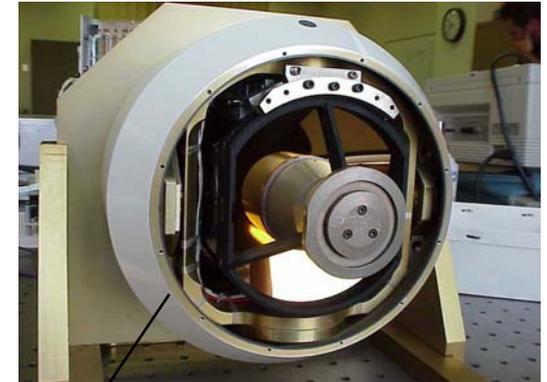


LOCAAS sensor:

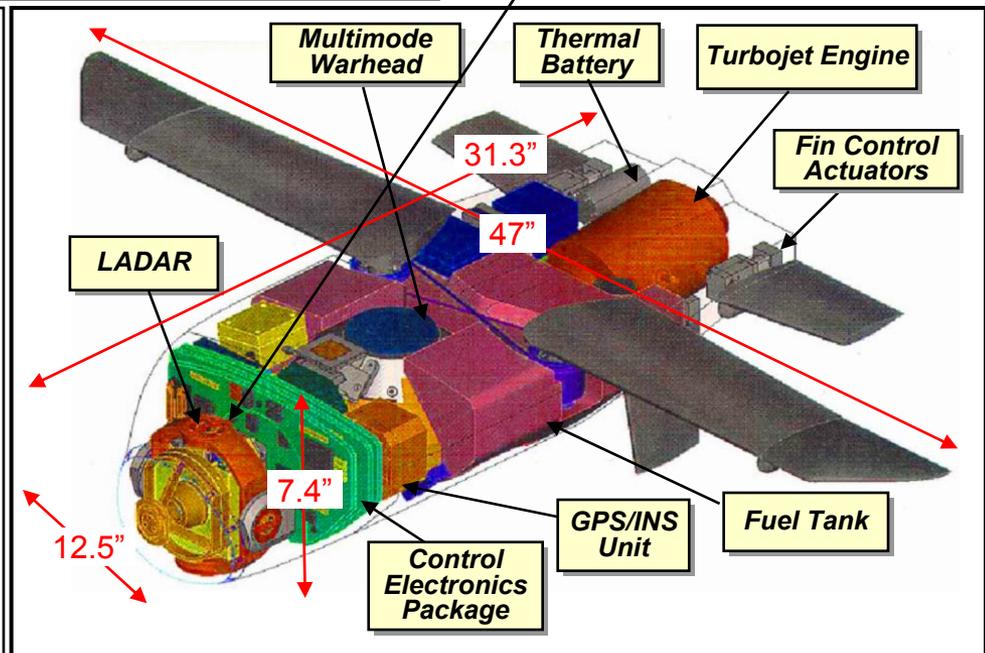
- Laser $P_T = 7$ W
- Aperture D_R (effective) = 8.6 cm
- Total $P_{\text{sensor}} = 400$ W
- Mass: 10 kg
- Volume (sensor + warhead) ≈ 8100 cm³

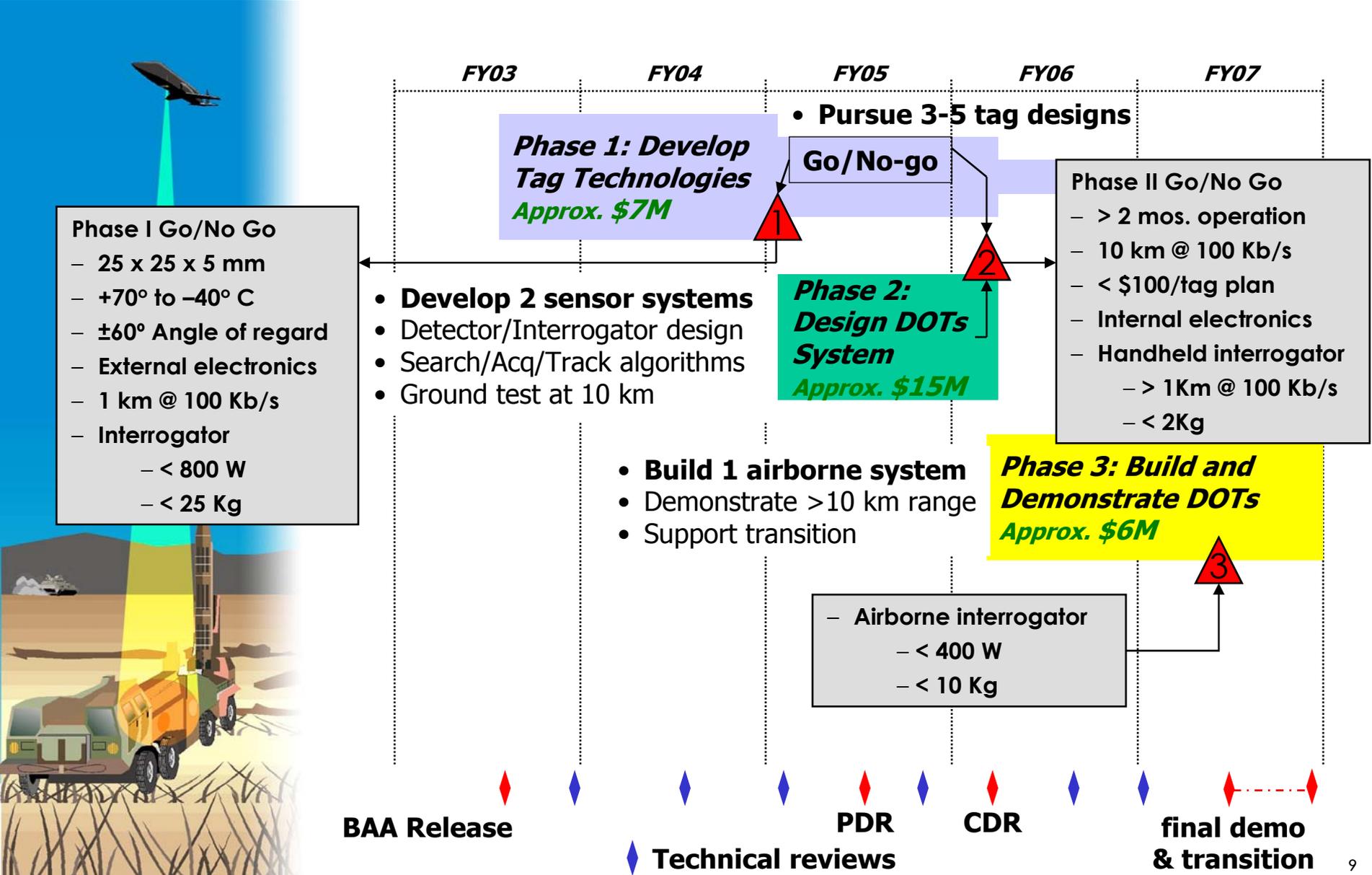
$P_T \cdot D_R$:

- Required: > 25 W-cm ($\lambda \sim 1.5$ μm)
- LOCAAS: 60 W-cm ($\lambda \sim 1.0$ μm)



COTS 20 W
1.5 μm fiber laser
Mass: 12 kg
Volume: $\approx 25,000$ cm³



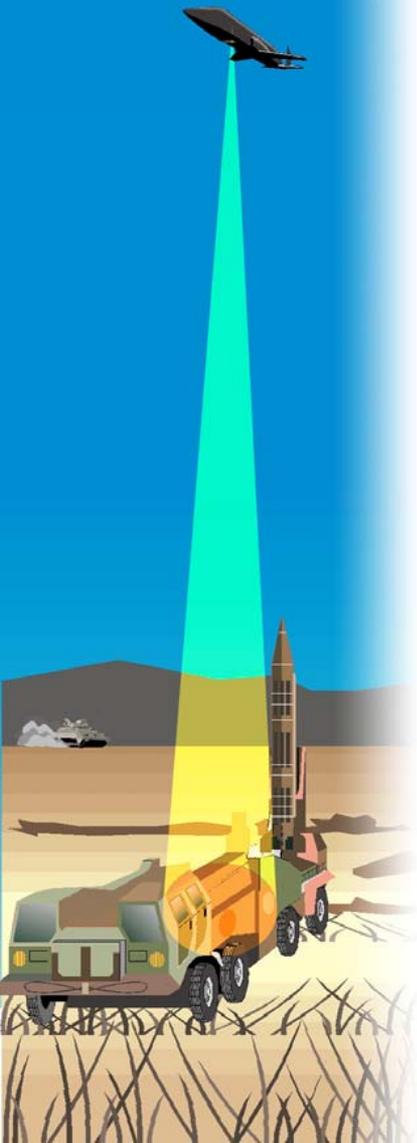




System Metrics



	System Metrics	Requirements
Phase I	Temperature range	-40 to 70 C
	Size	25x25x5 mm ³
	Acceptance Angle	± 60°
	Data Rate	100 Kb/s
	Bench Interrogator	< 800 W, < 20 Kg
Phase II	Lifetime	>2 mos.
	Handheld Interrogator	>1Km @ 100 Kb/s, < 2 Kg
	Operational Range	>10 km
	Eye-safe @ tag	$\Delta\lambda=1.3-2.0 \mu\text{m}$
Phase III	Airborne Interrogator	< 400 W, < 10 Kg
	Search/Interrogate	>1 km ² /min
	Low Cost	<\$100/tag



Questions??